Conodonts and Conodont Assemblages

by

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Introduction

This study was undertaken for the purpose of trying to determine whether or not conodont assemblages could be recognized in the Ohio shale. Assemblages, described by Scott (1934, 1942) and others, from different localities at other geological horizons were the examples for this study. The conodonts have been described and illustrated. In addition, similarities between conodonts and annelid worm parts have been discussed.

Conodonts, the microscopic tooth-like fossils long a mystery to paleontologists, have been known since 1856. However, "conodont assemblages were first described by Schmidt (1934) and Scott (1934)," and these dates mark the beginning of an entirely new concept regarding their zoological affinities. Whereas Schmidt ascribes his assemblages to primitive fish, Scott prefers to relate conodonts to marine worms. This relationship to either fish or worms was not a new idea, but with the finding of the assemblages a long step toward the correct identification of conodonts was taken.

The writer favors the association of conodonts with the marine worms and for this reason has limited the zoological remarks mainly to this relationship.

Inasmuch as Scott presents his material with such leanings, the writer has adopted his approach in the description of the conodonts from the Ohio shale. Specifically, this approach involves a description of each assemblage and an analysis of the resemblences of the conodonts to the worm parts.

The conodonts described in this report are in the collections of the Geological Museum at The Ohio State University. The writer was able to find very few conodonts in Ohio shale rock specimens collected by him in the field. This was not surprising since conodonts are not found with any uniformity of distribution in the rocks.

The writer is pleased to acknowledge his indebtedness to Dr. Grace A. Stewart of The Ohio State University who has directed all phases of this work, offering constructive criticism, aiding in the identification of specimens, etc., as well as instigating the initial interest in the subject. He is also indebted to Dr. Mildred Marple, Curator of The Ohio State Geological Museum, for allowing him to use the museum material for study. His best thanks are also due to Dr. W. H. Hass of the United States Geological Survey who has offered constant encouragement and many valuable suggestions.

Historical Resumé

One of the first men to look upon conodonts and attach specific paleontological significance to them was C. H. Pander in the year 1856. Pander considered these microscopic tooth-like fossils as the remains of fish related to the shark family and in his monograph which first used the name conodont, he describes some of the internal structure as well as their external character. A very good translation of this original work by a Mr. W. Ayvazoglau of the Geological Survey is partially given in Dr. Wilbert H. Hass' publication Morphology of Conodonts (1941, pp. 71-74). In spite of the fact that conodonts have been known and studied for over 90 years, their zoological relationships and the function they performed are still not certainly known. Many controversial conclusions have been offered by a score of workers over the years since the original publication, but none has been based upon completely conclusive evidence. In his earlier paper, Zoological Relationships of Conodonts (1934, pp. 449-450), Scott has outlined this controversy in unique style and in part it is here included.

"J. Harley appears to be one of the first to question Pander's disposal of conodonts. In 1861 he expressed the belief that they were the spines from animals similar to Limulus and Squilla.

In 1875 Pander's disposition of conodonts was questioned by J. S. Newberry of Ohio. After studying many specimens from the Cleveland shales (undoubtedly similar to the forms described in this paper), he suggested that they might be annelids instead of fish (Cyclostomata).

G. J. Hinde, in 1879, considered them as teeth of primitive vertebrate and compared them with the teeth of the existing myxinoids. He made extensive researches on the annelid jaws from the Isle of Gotland, England, Canada, and northeastern United States, and found many types of conodonts a associated with them. He compared the chemical composition of these two different types of fossil remains and found that they were radically different."

The rest of Hinde's evidence was equally as insufficient to conclude a definite origin.

"In 1884, U. P. James regarded them as the 'jaws and lingual teeth of mollusks.' Few others have followed that suggestion.

In 1886 Rohon and Zittel concluded that 'the conodonts have nothing structurally in common either with the dentine of Selachia and other fishes, the horny teeth of Cyclostomi, the lingual teeth of the Mollusca, the hooklets of the Cephalopoda, or the broken segment spines of the Crustacea; on the other hand, both in form and in structure, they agree remarkably with the masticatory apparatus of the Annelida and Gephyrea.'"

In 1921 W. L. Bryant compared the structure of conodonts to the structure of annelid jaws and concluded that conodonts were the remains of some primitive type of fish.

> "As early as 1878, Ulrich said that a 'striking resemblence' existed between conodonts and the chitinous jaws of living annelids.----But after many years of study, Ulrich and Bassler, in 1926, discussed the biological position of conodonts and published the first complete and satisfactory classification."

In this classification they concluded that conodonts were primitive fish teeth and recognized that they were not necessarily all of the same group.

> "In 1923, J. M. MacFarlane classifies them as an order "Conodonts" under the Malcodermata. He accepts them as the circumoral teeth of primitive members of that more primitive group of fishes, The Cyclostomata."
>
> "C. B. Stauffer and Helen Jeanne Plummer, in 1932, remark, 'It is evident that the solution of the problem lies near the fish.'
>
> In 1933, A. S. Romer said, 'I cannot accept them as the remains of vertebrates.'"

In addition to this resume presented by Scott in his earlier paper the writer includes some additional determinations on the relationship of conodonts to either fish or annelids.

In 1929, S. R. Kirk (1929, pp. 493-496) found conodonts associated with the fish fragments of the Harding sandstone (Ordovician of Colorado), and moreover, some of these specimens showed "basal attachment to fragments of plates, identical in composition with the fish plates which are so abundantly scattered through the various beds of the Harding." Kirk does not commit himself however, as to their classification based on this single phenomena, but does point out the lack of evidence supporting this relationship in better known conodont-bearing formations.

Wilbert H. Hass, in his article on Morphology of Conodonts concluded that, "(1) ----conodonts are to be viewed as a morphologic unit. (2) The so-called species of conodonts are quite variable entities, the individual changing greatly in ontogenetic development. (3) Conodonts functioned as internal supports for tissues within or on the body of some marine organisms at places subjected to stresses." All of which serves to indicate that still not enough evidence could be found to permit definite zoological association.

In the year following the publication by Hass, H. W. Scott prepared a paper published in the Journel of Paleontology (1942, pp. 293-300), describing additional ~~conodonts~~ assemblages from the shales of Montana and reinforced his earlier views on their affinity to the annelid worms. The writer was hoping to find something comparable to Scott's conodont associations in the specimens recovered from the Ohio shale. However, only a few similarities have been found. It is believed that more thorough collecting will lead to evidence of a more determinable character.

Zoological Affinities

Conodont Occurrences

One of the universally accepted facts concerning conodonts is that they are derived from an animal that preferred a marine environment. A further definition of the environmental details is not possible for these fossils have been found from rocks representing various origins. It seems logical, then, to assume that the conodont-bearing animal was not restricted to particular environs, but was able to adapt itself to water either turbulent or quiet, shallow or deep, and that a food source must have been equally as widespread. However, conodonts are not universally common in marine rocks, nor even throughout the best-known portions of geologic time. They are recognized from the Ordovician to the Permian and in more recent years, a few have been found in rocks of Triassic age. Usually they occur along the bedding planes in shales in restricted areas both geologic and geographic. The collector is very fortunate, therefore, if he happens to discover these rare occurrences in the course of his field work.

Dr. W. H. Hass of the U.S. Geological Survey, found quite a large conodont fauna at the base of the Bedford shale in the vicinity of Chillicothe, Ohio. The specimens were obtained from samples collected near the well-marked Ohio black shale-Bedford gray shale contact that is exposed in several ravines in this locality. In addition to the conodonts a small marine gastropod and a species of Lingula were the only other specimens observed. In a subsequent search for specimens from the identical localities, guided first by a map marked by Dr. Hass, and later by his personal guidance in the field, the writer did not find a single entire conodont. A few small ~~shell~~ conodont fragments were recovered after utilizing various methods of separation, and the afore-mentioned gastropods and brachiopods were found.

This patchy distribution leads the author to believe that the animals were possibly colonial in habit and migratory in a restricted sense of the word.

Scotts "ideal assemblage"

Conodonts resemble the hard parts of numerous animals and as can be surmised from the historic resumé they have actually been classified under many Phyla by different workers. Certain basic specifications of conodonts, such as size and form, limit the number of possible classifications, and detailed information, such as reported by

Hass and Scott, limit the possible classes even more. Scott has produced evidence showing the similarity of conodonts to worm parts and has designed an "ideal assemblage" composed of conodonts that most nearly resembles a worm jaw assemblage. Therefore, as well as presenting Scott's "ideal assemblage" the writer has added a description of certain worm parts that are similar to conodonts.

Though Scott seemed very certain of the annelid relationship to conodonts in 1934, the "ideal assemblage" was proposed merely to show that several types of conodonts might come out of one animal. The writer believes that the proposal also offers evidence supporting annelid affinities. Scott describs the function of his assemblage as follows:

> "Such an apparatus would not only form an excellent screen to prevent undesirable objects from entering, but would also present a formidable barrier for the escape of desirable food once it had passed beyond the battery of teeth. The manipulation of the assemblage would not be a difficult matter. Insofar as manuverability is concerned, it could operate with equal ease as the jaw apparatus of an annelid or as the gill rakers of a fish."
>
> (Scott, 1942, p. 298)

Additional quotations from Scott's description accompany the copy of his illustration. (Figure 1)

Explanation of Figure 1

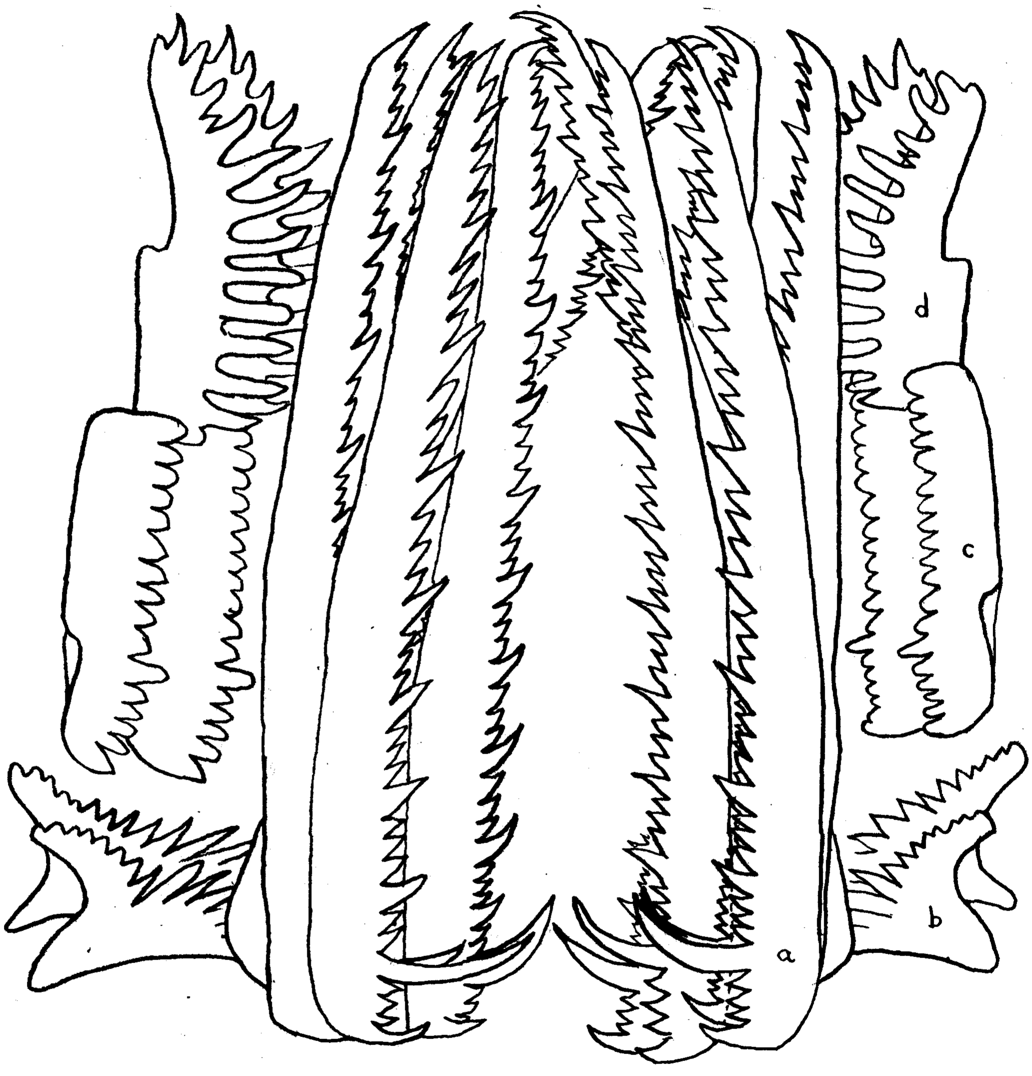
Scotts' "Ideal assemblage"

(1942, p.298, Fig. 1)

"Lockriea montanaensis Scott, n. gen., n. sp. a, Kindeodell part; b, prioniod part; c, spathognath part; d, prioniodell part. Position of b, c, and d inferred. Approximately x 30."

"The assemblage in figure 1 is not necessarily oriented with the anterior end directed toward the top of the page. The inclination of the denticles has been assumed by all workers to be in a posterior direction, and the point of attachment at the escutcheon was therefore anterior. --- the prioniods have been oriented with the denticles more or less parallel to the hindeodells, and the escutcheon, in all cases, is directed to the outside of the assemblage. The prioniods, prioniodells, and spathognaths may have been set further forward or back than shown."

Figure 1



Though it is quite apparent that he no longer wishes to state definitely the connection of this "ideal assemblage" to the mouth parts of an annelid, certain other evidence observed by Scott seems to indicate this relationship. Foremost among the clues is the well-illustrated point that there is a definite lack of any other kind of hard part found with the assemblages. In the gentle environs prevalent during the initial preservation of the conodonts from the Big Snowy embayment (Scott, 1942, p. 297), this absence of other hard parts is indeed a significant fact and in the writer's opinion, could logically point toward a worm relationship.

Selected physiology of Worm parts

In the sub-kingdom of Metazoa, Phylum Annelida, the class Chaetopoda is further subdivided into Oligochaeta (terrestial and fresh-water), and Polychaeta, (marine) families. The species Nereis dumerilii is perhaps one of the better known marine worms of the Polychaeta. Several illustrations of this form have been copied from Parker and Haswell's Textbook of Zoology, 1947 (pp. 306-340). The similarities between conodonts and the selected illustrations of the worm parts are emphasized. (Figure 4 to 10)

Explanation of Figure 2

Anterior segments of a modern annelid showing the position of the parapodia on the segments.

Explanation of Figure 3

A single parapodium, magnified: The setae are labeled (S). (Parker and Haswell, p. 310, Fig. 278. - Nereis dumerilii)

Explanation of Figure 4

Setae of various Polychaeta. (From Claparède.) (Parker and Haswell, p. 335, Fig. 299.) Note the similarities to conodonts; eg. Hindeodella.

Explanation of Figure 5

Diagrammatic sketch of a single parapodium with hypothetical conodont serving as an internal structural support.

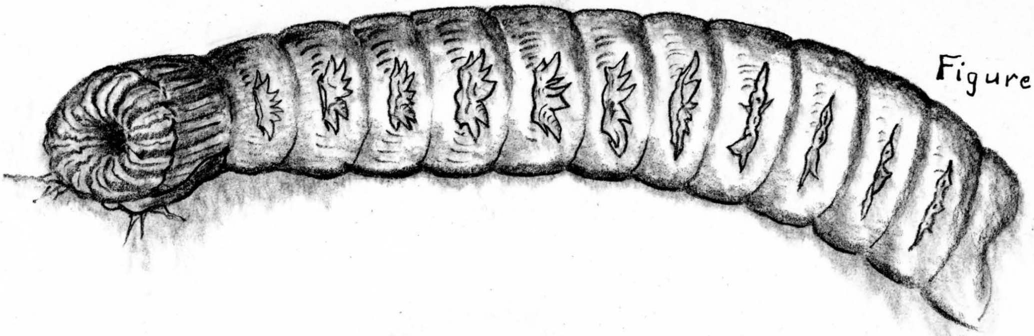


Figure 2

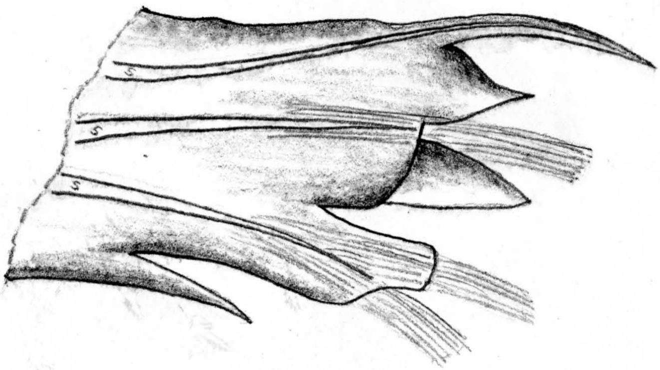


Figure 3

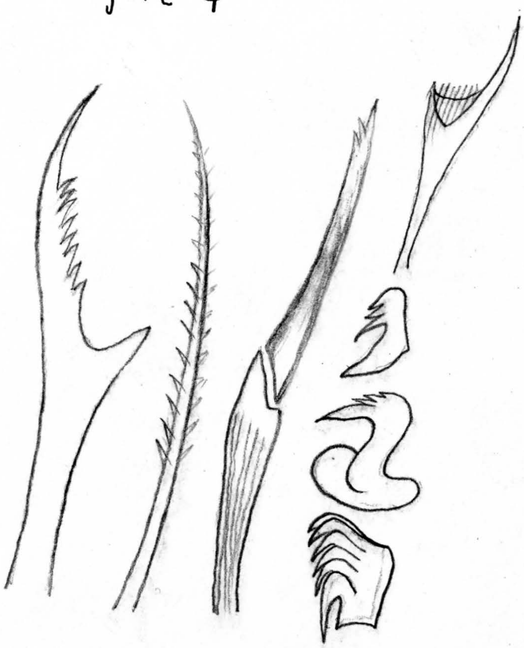
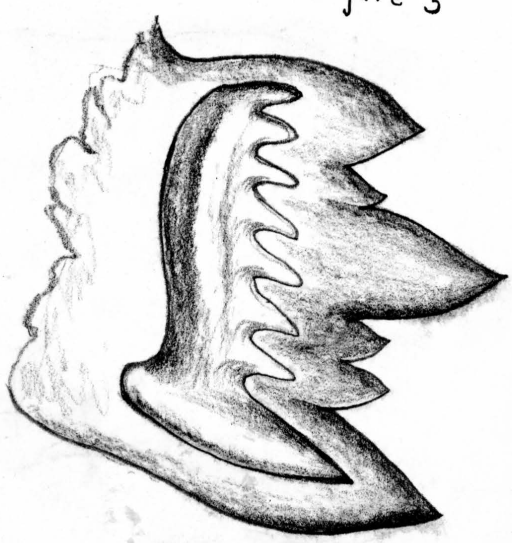
Figure 4


Figure 5


Explanation of Figure 6

Semi-diagrammatic view of the anterior portion of the body of Nereis dumerilii, showing the retracted position of the jaw assemblage. (Parker and Haswell, p. 313, Fig. 281.)

Explanation of Figure 7

Head of Nereis dumerilii with buccal region everted. (ventral view, ca. 20x). (Parker and Haswell, p. 312, Fig. 280, B)

Explanation of Figure 8

Diagrammatic representation of proboscis typical of the class Nemertini of the phylum Platyhelminthes. (Parker and Haswell, p. 268, Fig. 231, A (retracted position), B (everted position)). The diagram is suggestive of the mechanics involved in the manipulation of the mouth parts of Nereis dumerilii.

Figure 6

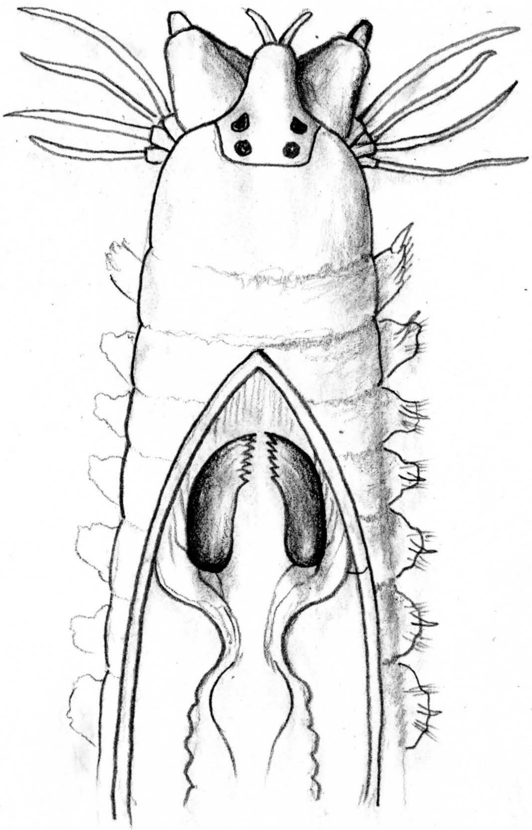
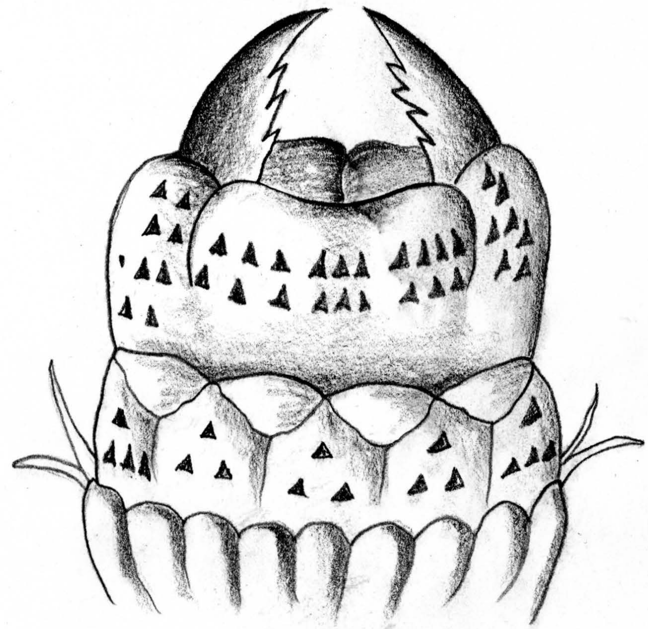


Figure 7



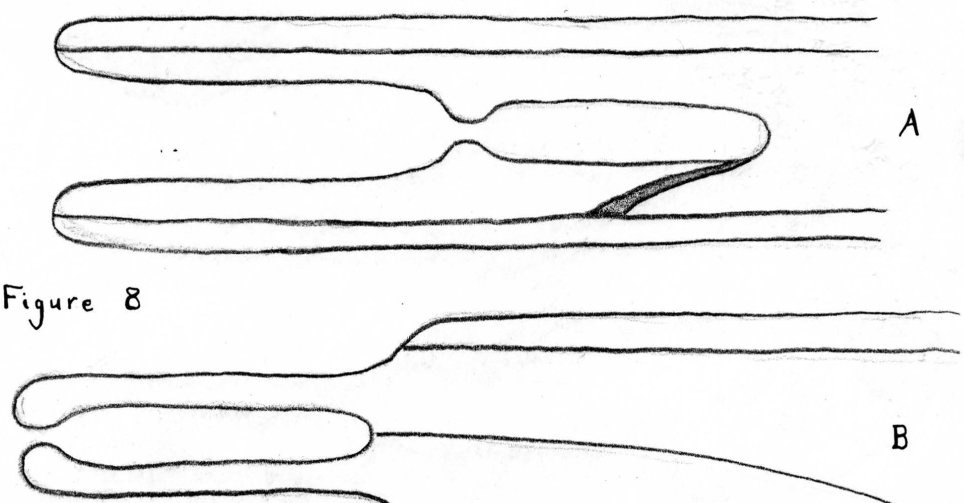


Figure 8

In addition to the hard parts in the head of the animal, several species are equipped with hard parts that serve as strengthening supports for the parapodia. Of specific interest here, the authors say, (pp. 334-336)

> "Parapodia are lateral hollow processes of the body wall bearing a number of bristles or setae.-----The setae are nearly always chitinous; in Euphrosyne they are calcified.-----Sometimes the setae are quite short, projecting little beyond the parapodia, and are hook-like or comb-like. -----Each setae is lodged in a sac, the setigerous sac, formed by an invagination of the integument, and lined by cells continuous with the epidermis. Each seta is derived from one of these cells, and is to be looked upon as a specifically developed part-----of the general outer surface."

The jaw parts of annelid worms are as diversified in form as are the setae. The outline drawing by Treadwell (1911, pp. 6-9) (Figure 10) indicates the similarity to the general external characteristics of conodonts, but fails to show a specific relationship to known assemblages. In every known living species of Polychaeta the hard parts of the mouth are dominated by a pair of forcep-like jaws that work in coordination with a variable number of denticulated parts. Muscle fiber connects all these parts, one to another, in the compact formation of an ingestive apparatus. Of special interest, is the fact that in most

Explanation of Figure 9

Outline drawing of the jaw parts (maxillae) of a modern annelid worm (_Aracoda spatula_); copied from a drawing by Aaron L. Treadwell. (ca. 25x).

Explanation of Figure 10

Outline drawing of the jaw parts of an annelid worm (_Nicidion Kinbergii_); copied from a drawing by Aaron L. Treadwell. (ca. 30x) Note the similarity between the maxillae of this species and the forms exhibited by conodonts.

Explanation of Figure 11

Outline drawing of the jaw parts of a modern annelid worm (_Aracoda attenuata_), copied from a drawing by Aaron L. Treadwell. (ca. 75x)

(Treadwell, 1911, pp. 6 - 9)

Figure 9

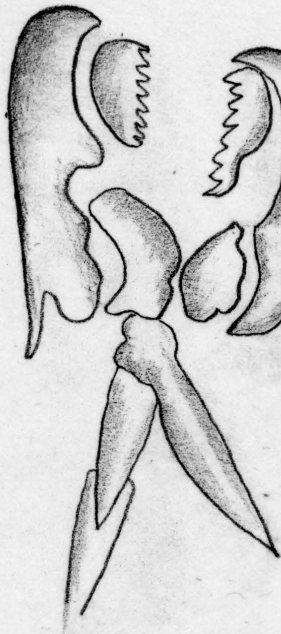
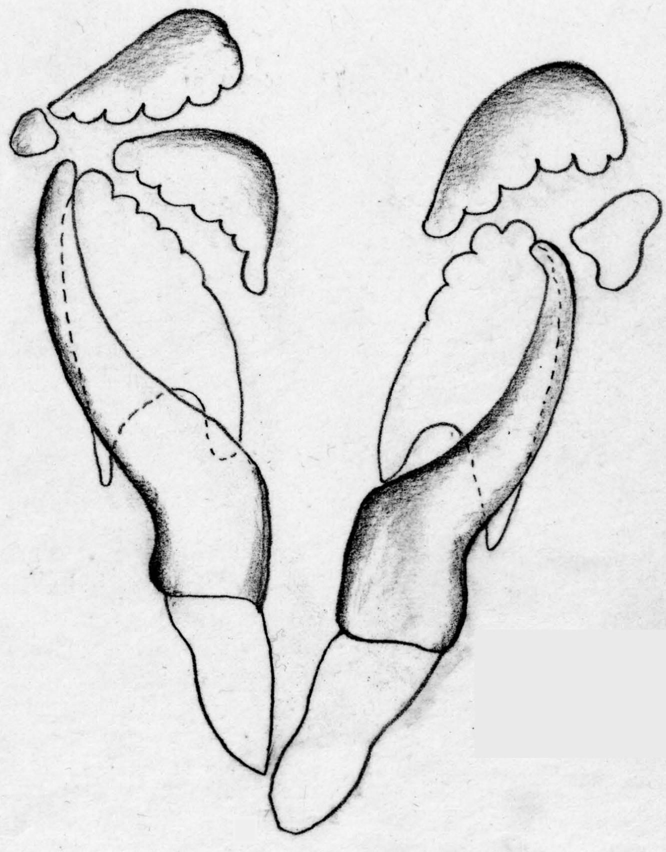


Figure 10



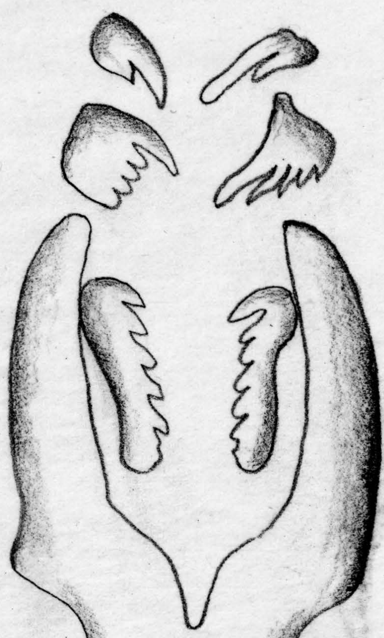


Figure 11

worms of this type the entire assemblage is protractile, the normal position being one of invagination to the interior of the animal. (See figure 6). This fact must be considered carefully when examining the "ideal assemblage" proposed by Scott. (Figure 1) The complexity of the apparatus is definitely limited by the maneuverability required. On the other hand, the existence of such a proboscis does allow for innumerable individual forms to be found in one assemblage. The author has also noted that the symmetry between the paired forms in both the living worms and the conodont pairs is not exact and in some cases the second member of a pair does not even exist. However, such phenomena are quite common throughout the animal kingdom.

Conodont and Annelid relationships

Two problems confront the paleontologist in classifying the Gonodonts. One is the difference in chemical composition between conodonts and worm parts. The other is the lack of wear on the points of the denticles of the conodonts, which would be impossible if they were used for masticating purposes. The quotation from the textbook of zoology concerning setae (page 18) and ideas expressed by Hass (1941) and Scott (1934, 1942), offer some light on both these problems.

It has been previously quoted (page 18) that living worms of some species contain hard parts of calcareous composition, though ordinarily all the hard parts are chitinous. Concerning the chemical composition of conodonts, Scott says,

> "It is probable that one family of Paleozoic annelids possessed a jaw apparatus composed of teeth which we call conodonts; whereas, a second family possessed teeth known as scolecodonts. Those possessing conodonts died out at the close of the Paleozoic; whereas, that family having the scolecodont type of teeth lived on to the present, giving rise to such forms as the modern Nereis and relatives."
>
> (1934, p. 455)

Obviously, he refers to the chitinous material of the scolecodonts as opposed to the apatitic composition of conodonts that is suggestive of vertebrates.

In addition to providing the clue concerning the calcareous composition of conodonts, the quotation from the textbook of zoology (page 18) supports the ideas advocated by Dr. Hass (1941, p. 81) on the general lack of wear exhibited on the oral surfaces, and the rejuvenation of broken denticles.

> "-----a rejuvenation of parts could have taken place only so long as the conodont was actually covered by a secreting medium,-----"

Inasmuch as the setae can be everted and retracted in living species and when retracted are more covered than not, it is feasible to conclude an evolution from a family of worms whose setae remained as an internal support for the parapodia, and thus was covered with a secreting medium all during their existence. A few of the forms exhibited by the setae (Parker and Haswell, 1947, p. 335) show a remarkable resemblence to those of conodonts, and by design the writer imagines several possible positions for conodonts as this internal support for the leg-like appendages. (See figure 5)
The fact that conodonts occur in "lefts" and "rights" and in bilateral symmetry as opposed to ventro-dorsal, is further evidence supporting annelid relationships. They may logically be more closely related to the setae of the parapodia than, indeed, to the jaws.

The third possibility of a relationship between the conodont assemblages and the hard parts of annelids is found in the consideration of the former actually being a combination of parts from both the parapodia and the jaw. Such a proposal calls attention to the fact that the internal structure of parts from one appendage would not likely be identical to the structure of the other parts. This relationship is found in conodonts belonging to different genera, but such a combination of genera have not yet been found in the same assemblage.

Additional proposals could be advanced for the origin of conodonts along many zoological lines of reasoning much in the same way as in the analogy to the worm parts. However, in the light of present evidence that is admittedly scanty, the writer prefers to compare conodonts to the hard parts of the annelid worm.

Description of Material

Methods of Approach

As previously stated, the writer intends to use the methods established by Scott in the analysis of the conodonts presently being considered. Hence, a brief review of part of his presentation is included to show his approach.

From Scott, the writer has borrowed the idea of describing the individual conodonts from the standpoint of a preferred orientation that arises from the belief that several of the specimens originally were parts of one animal. In addition, other criterion of long standing are followed. For instance, most students of conodonts agree that certain external characteristics determine the orientation of an individual. Some of the more self-evident of these features are as follows: The points of the denticles are upward or oral and conversely, the basal portion of the conodont with the attachment scar is downward or aboral. The denticles are inclined backward or posterior and the convex curvature of the longitudinal axis of a blade or bar is the side closest to the outside of the animal. The nomenclature used for the various parts of the individual, such as anticusp, lateral ridge,

Explanation of Figure 12

(Classification based on external characteristics by Bond and Huddle)

Four conodonts that are typical of these fossils found in Ohio, with the major external features labeled according to common usage.

A, Genus <u>Hindeodella</u>
- a, anterior end
- b, bar
- d, denticles
- f, aboral surface
- p, posterior end

B, Family <u>Prioniodidae</u>
- a, anterior end
- c, terminal cusp
- d, denticles
- e, anticusp
- f, aboral surface
- lr, lateral ridge
- o, oral surface
- p, posterior end

C, Family <u>Prioniodinidae</u>
- a, anterior end
- b, bar or blade
- c, subcentral cusp
- d, denticle
- f, aboral surface
- g, escutcheon
- lr, lateral ridge
- o, oral surface
- p, posterior end

D, Family <u>Distacodidae</u>
- c, cusp
- f, aboral surface
- k, keel
- pc, pulp cavity

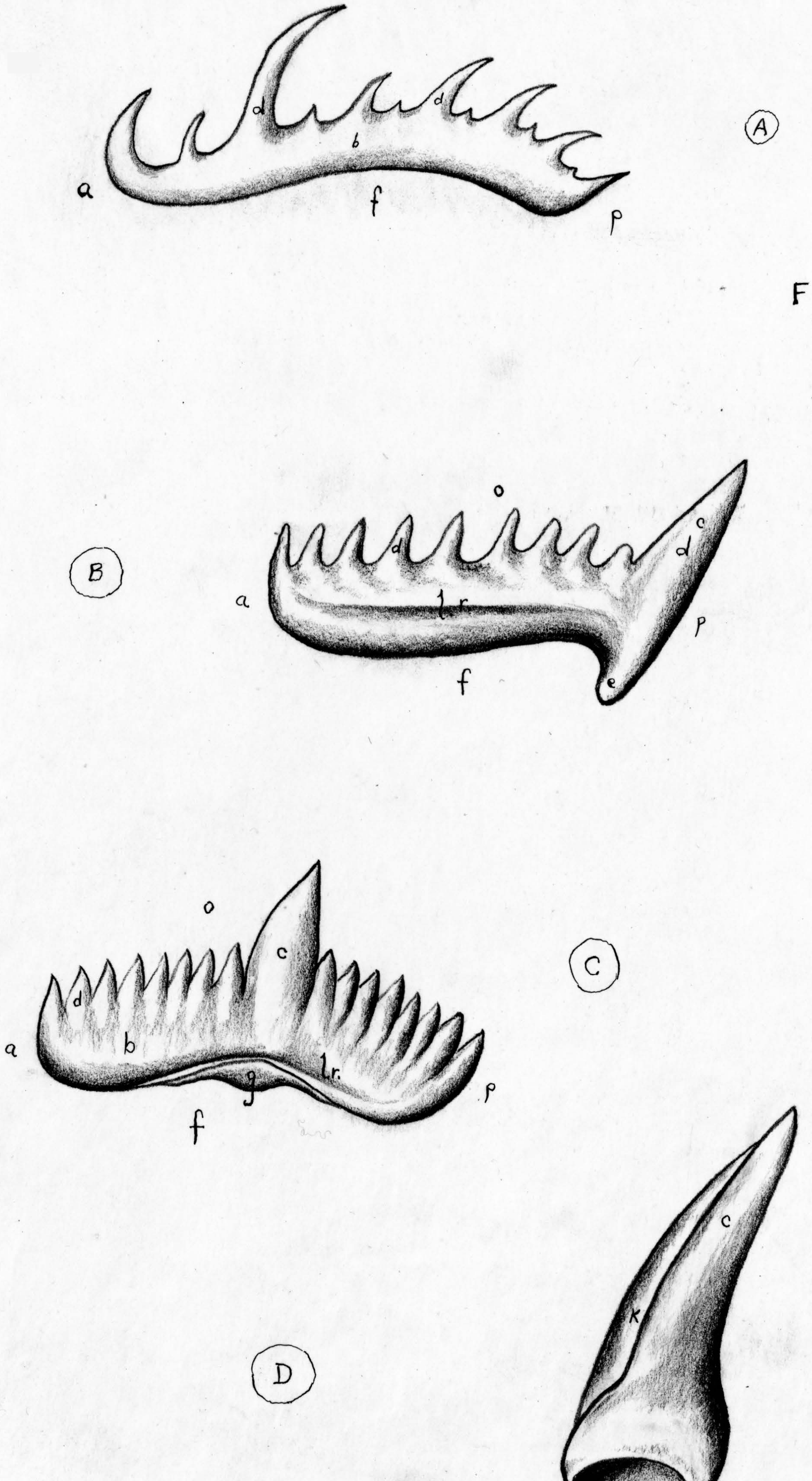


Figure 12

bar, cusp, escutheon, pulp or basal cavity are the standard names used for conodonts features.

Description of Scott's assemblages

Since Scott has been a student of conodonts for many years, he has examined thousands of individual conodonts in the course of his studies. From some of these occurrences he detected unusual relationships, ~~relationships,~~ which gave rise to his idea of conodont assemblages. Scott is certain that these specimens were not thrown together by chance, or by natural phenomena, as coprolitic deposits, or collections caused by gentle ocean currents sorting the material into some natural depression on the ocean floor. In all, over a hundred assemblages "in various stages of perfection have been recovered from the Montana material." Two of the assemblage descriptions are herewith presented as well as a copy of the illustrations that accompany them. Both of these groups are from the Quadrant shales and whereas the ~~first~~ second is similar to the material studied by the author, the ~~second~~ first is perhaps more illustrative of the relationship between conodonts and Scott's "ideal assemblage".

Explanation of Figure 13

"Assemblage Two"

Plate 58, figure 2

(Scott, 1934, p. 451)

"Assemblage Number Two consists of eight well-preserved specimens of Hindeodella. The denticles of four of these specimens point to the left and the denticles of the remaining four point to the right. All of the individuals are well-preserved, easily identified and seem to have maintained their natural position. They probably represent the actual position of the teeth in the mouth of the animal. There is a slight tendency for the bars to converge anteriorly. They may have been set in a semi-circle as is the mouth of an annelid."

Explanation of Plate 58
Figure 2 - Eight Hindeodellas.

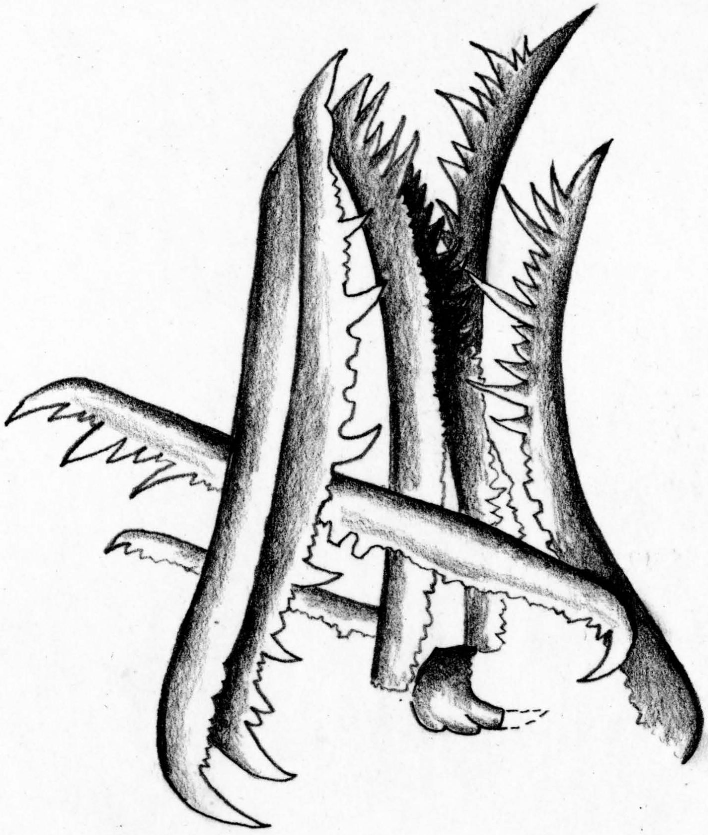


Figure 13

Figure 14

Explanation of Figure 14

"Assemblage Eleven"

Plate 59, figure 11

(Scott, 1934, p. 452)

"Assemblage Eleven is a fairly complete and well preserved group. It consists of the following paired forms: Prioniodus, Hindeodella and Prioniodella (?). The left member of Prioniodus is on the outside of the assemblage with the denticles pointing posteriorly and the main cusp on the inside. The denticles of the right member of Prioniodus (preserved as an imprint and illustrated as seen) point outward with the main cusp toward the anterior end. The specimens of Hindeodella lie with their denticles pointing outward and the two converge to a point posteriorly. In the anterior end of the right side of the assemblage are imprints of two broken specimens of what appears to be Prioniodella. There is also an imprint of an unidentified specimen in the center of the assemblage with the denticles pointing anteriorly. It is impossible to determine with any degree of accuracy the genus of the latter individual."

Explanation of Plate 59

Figure 11 - (a) Prioniodus, (b) Hindeodella,
(c) Prioniodella (?).

Description of Assemblages

General

The museum specimens that are described in this report have all been originally collected from the Ohio shale. Little information is given concerning the exact geographical location and no collecting data that refers to the exact stratigraphic horizon within the formation could be found. However, since the problem is not one of stratigraphy, only an approximate geographical location has been used to identify the specimens. All the rock specimens examined were slabs of black shale from 1/4 to 1/8 inches thick and approximately two by three inches in area. (Figure 15) Conodonts were observed on both sides of the specimens, but were described from one bedding plane only, at the place of greatest concentration.

Specimen No. 15792 was collected at Ealy's Mills near Gahanna, Ohio and presents the best of the conodont faunas among the rocks examined. (Figure 15) A remarkable number of conodont specimens lie in place upon a bedding plane of this rock in association with one another that suggests the assemblages described by

Explanation of Figure 15

Plan view of rock specimen number 15792 (actual size). This rock is in the Geological Museum at The Ohio State University and was collected from the Ohio shale at Ealy's Mills, Gahanna, Ohio. The red lines indicate the division of the rock into smaller sections convenient for study. The conodonts appearing in the numbered sections eight through twenty-seven have been mapped in larger scale (ca.32x), in figure 23 (in pocket).

Explanation of Figure 16

Plan view of rock specimen number 4080 (actual size). This rock was collected from the Ohio shale at Bedford, Ohio and is also in The Ohio State Geological Museum. Assemblage number four is located at area (a) and assemblage number five at area (b). The section index was not completed because too few conodonts were observed.

Figure 15

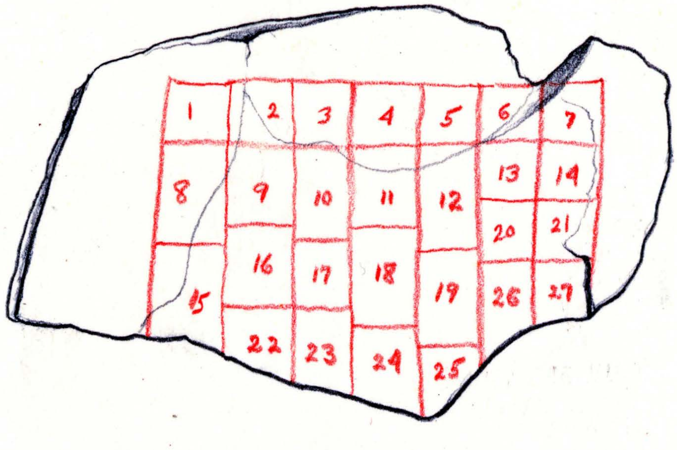
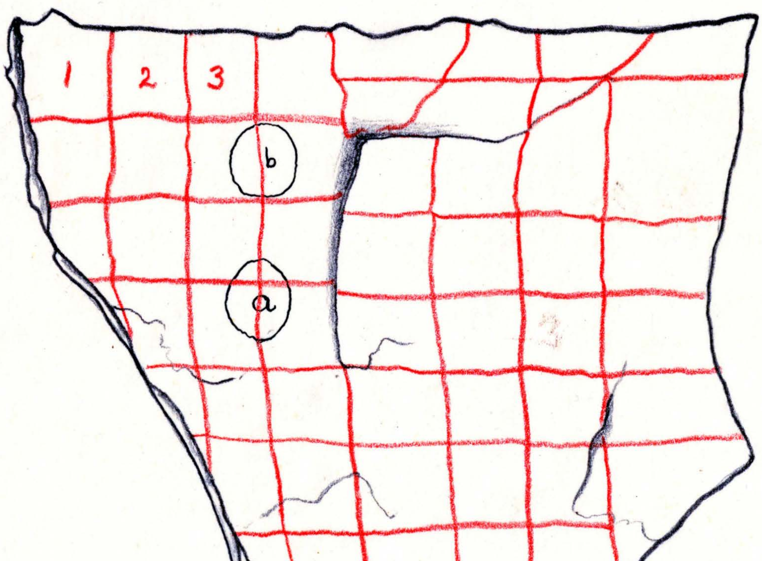


Figure 16



Scott. In order to distinguish the individual groupings from the whole, an index map is presented, charting the groups by means of an arbitrary layout of segments numbered in sequence. (Figure 23 in pocket) It is believed that this collection represents the original site occupied by several worms soon after their death.

Specimen No. 4080 was collected at Bedford, Ohio and is similar in all respects to the one previously described. It does not exhibit as large a fauna as the first. (Figure 16)

In addition to the museum specimens examined, numerous rocks collected somewhere from within the Bellefontaine outlier by S. L. Schoff were looked at briefly, to determine their conodont content. Many fragments of specimens were observed, but entire conodonts were rare and showed little resemblence of being grouped in assemblage-like patterns. Therefore, it was concluded that the conodonts had been greatly disturbed sometime after being deposited and did not represent the remains of a single animal. A single exception among these specimens, shows six small, poorly preserved conodonts that may be from one animal and for this reason they are described as an assemblage. (Figure 22).

Assemblage Number One

Conodont assemblage number one is located in the upper left hand corner of section eleven, rock specimen number 15792 (See figures 15 and 23). This group consists of three pairs of the genus Spathognathodus (a) and a pair of impressions that were possibly made by the genus Subbryantodus (b). Lack of Hindeodella pairs near this group indicate an incomplete assemblage. The individual specimens are disarranged, preventing any description of their original orientation. Definite evidence indicating paired forms is apparent in the external structural characteristics of the individuals.

Legend: a, Spathognathodus

b, Subbryantodus

i, impression

Dashed line indicates margin of rock cover

Magnification; ca. 32 x

Figure 17

Figure 17

Assemblage Number Two

Conodont assemblage number two is located on the line between sections fourteen and twenty one, rock specimen number 15792 (See figures 15 and 23). An incomplete assemblage again indicating the Spathognathodus (a) Subbryantodus (b) association in pairs. The pair of the specimen of Bryantodus (c) possibly is located in section eight of the same rock specimen. The existence of Bryantodus and Subbryantodus in the same assemblage is considered reasonable by Scott (1942, p. 300). The description of the original orientation is not possible, but it is believed that the proximity of the conodonts to one another is indicative of an origin from one animal.

Legend: a, Spathognathodus

b, Subbryantodus

c, Bryantodus

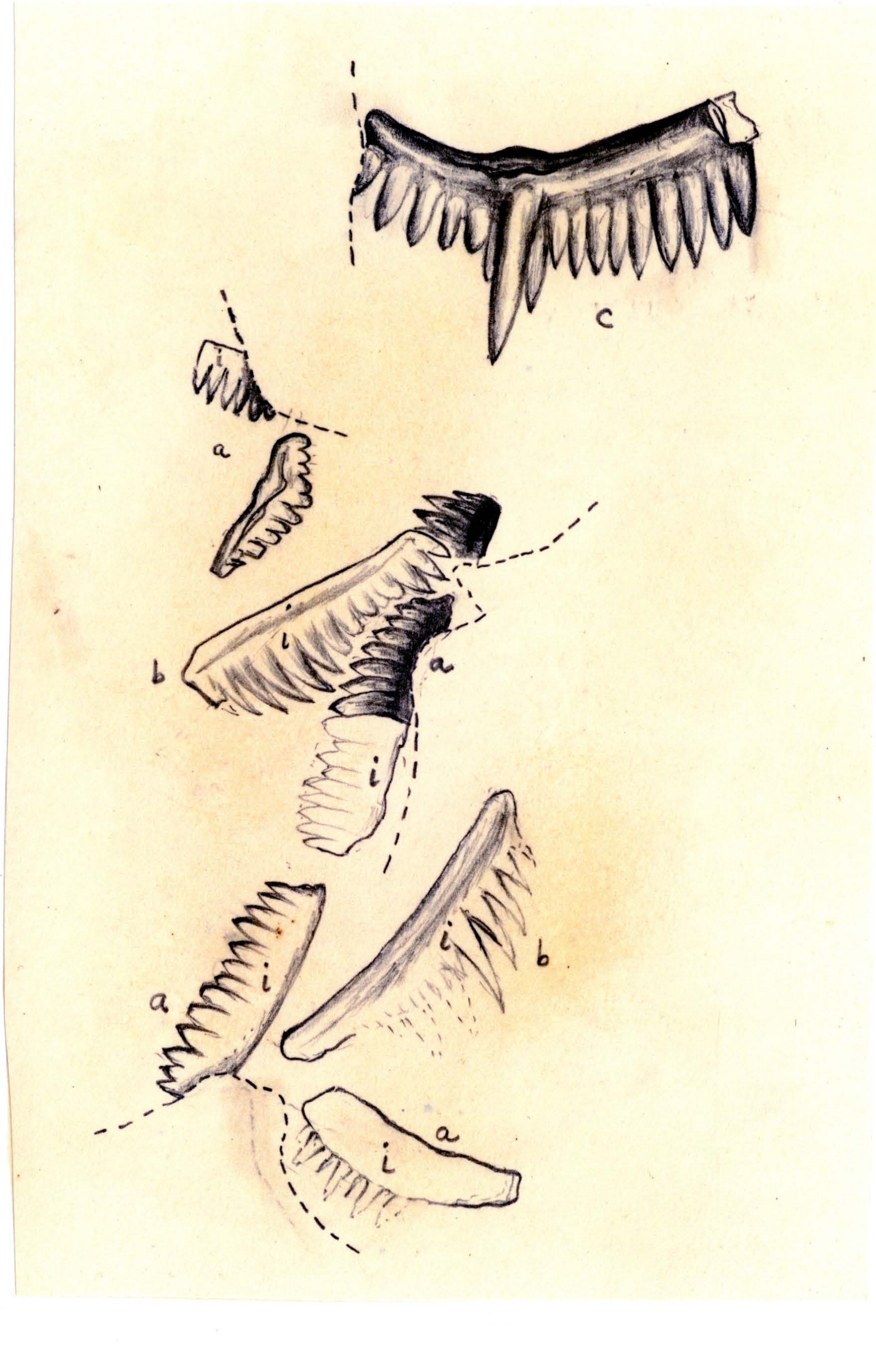
i, impression

Dashed line indicates margin of rock cover

Magnification; ca. 32 x

Figure 18

Figure 18



Assemblage Number Three

Conodont assemblage number three is located in section twelve and on the line between sections twelve and thirteen, rock specimen 15792 (See figures 15 and 23). Three specimens of the species Spathognathodus aculeatus (Branson and Mehl), (a), appear to be the right members from paired forms. Their counterparts are not found on this rock. At least two species of Hindeodella (b) are represented in this group and their size indicates that they originated in the animal that bore the Spathognaths. A well preserved pair of Spathognathodus inornatus (Branson and Mehl), (c), is found with this group. No orientation of the assemblage is possible due to the scattering of parts at, or shortly after, deposition.

Legend: a, Spathognathodus aculeatus

b, Hindeodella

c, Spathognathodus inornatus

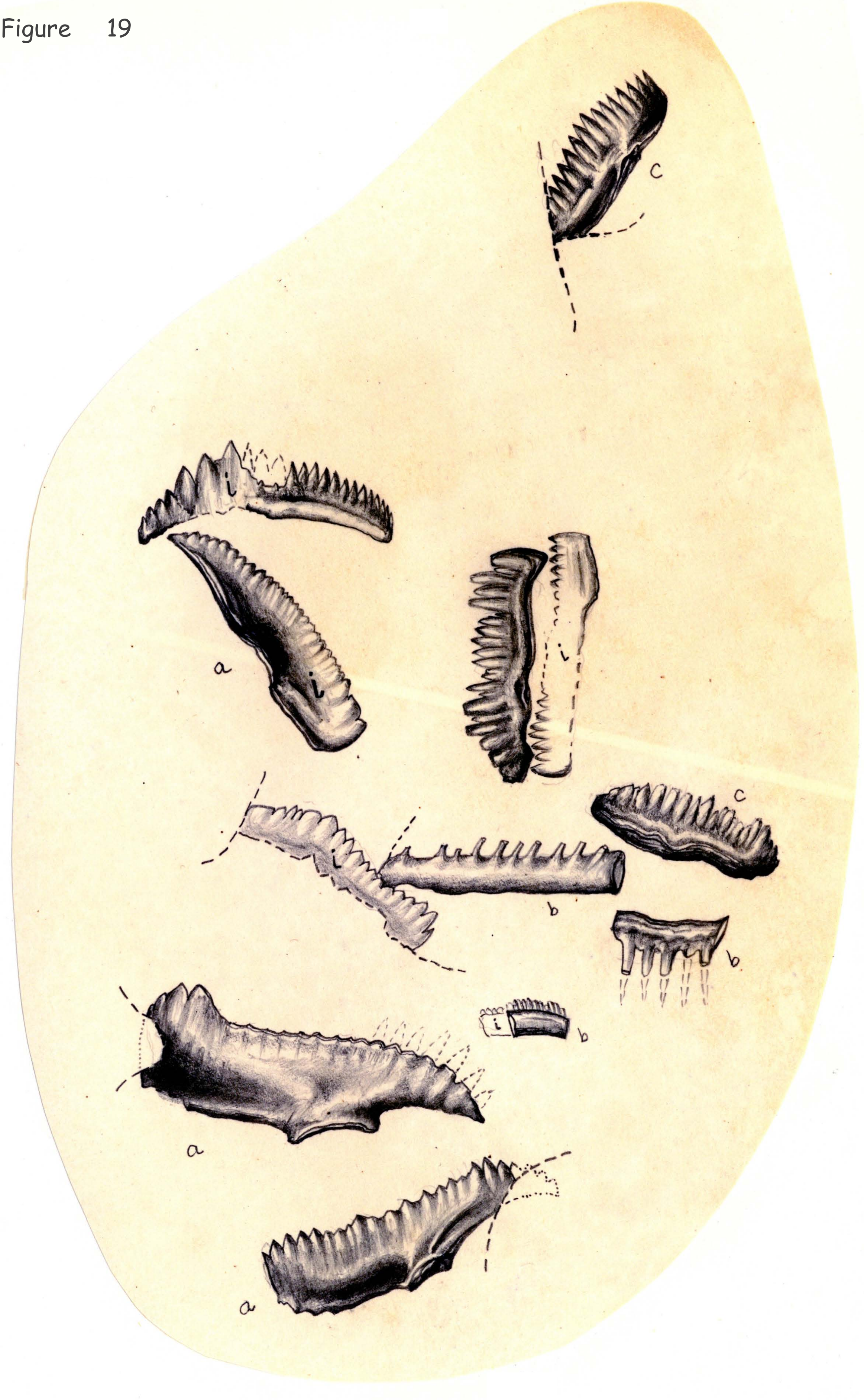
i, impression

Dashed line indicates margin of rock cover

Magnification; ca. 32 x

Figure 19

Figure 19



Assemblage Number Four

Conodont assemblage number four is located at position (a), (See figure 16), rock specimen 4080. Several individual specimens of the species Spathognathodus inornatus are observed as left and right members of a pair and are associated with a pair of Spathognathodus aculeatus (a). The individuals shown represent a very incomplete assemblage, but the association between the two species of the Spathognaths is the same as that found in the rock from Gahanna, Ohio.

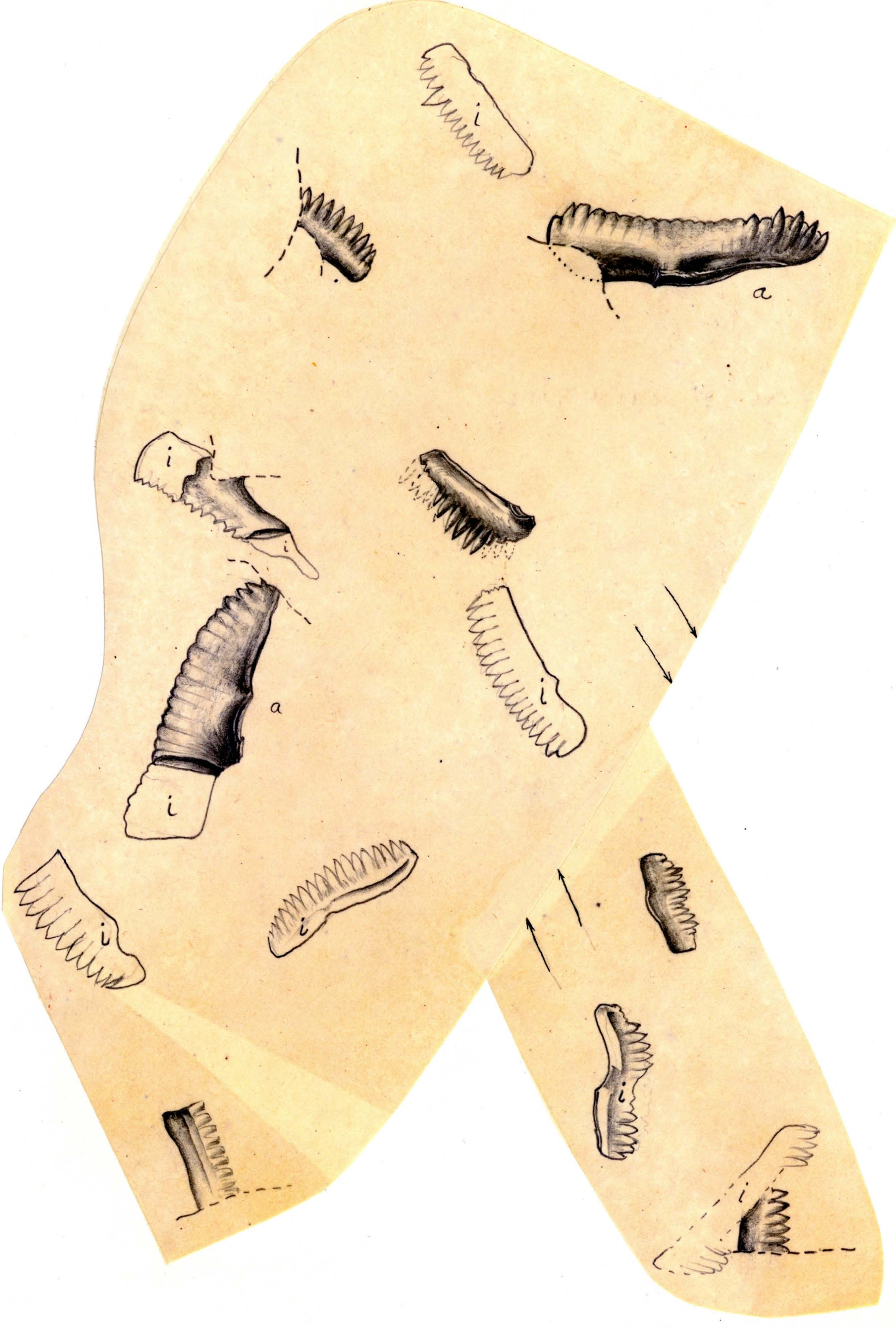
Legend: a, Spathognathodus aculeatus

i, impression

Dashed line indicates margin of rock cover

Magnification; ca. 32 x

Figure 20


i
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Assemblage Number Five

Conodont assemblage number five is located at position (b), (see figure 16), rock specimen number 4080. Though no complete pairs of Spathognaths are preserved in this group of conodonts, their impressions (a) indicate that they are all of one species and size. This fact indicates that they possibly originated in one animal. These individuals are associated with a specimen of Hindeodella (b) which is the same association observed in assemblage number three. (Collectively, assemblages number four and five, from Bedford, Ohio, show the same association of Spathognaths and Hindeodells as observed in assemblage number three, from Gahanna, Ohio.)

Legend: a, Spathognathodus

b, Hindeodella

i, impression

Dashed line indicates margin of rock cover

Magnification; ca. 32 x

Figure 21

Figure 21

Assemblage Number Six

Conodont assemblage number six is located on a bedding plane of a rock collected from the Bellefontaine outlier (Devonian, west-central Ohio). The distribution of the conodonts are shown at (a) figure 22. Though none of the specimens appear to be arranged in any sort of an original position, the similarities in their sizes and the nature of their preservation indicate that they possibly originated in one animal. The association of Hindeodells (b) and Bryontods (?) (c) is not uncommon in conodont assemblages from other areas.

Legend: a, map of rock specimen indicating the position of the conodonts found in assemblage number six.

b, Hindeodella

c, Bryantodus (?)

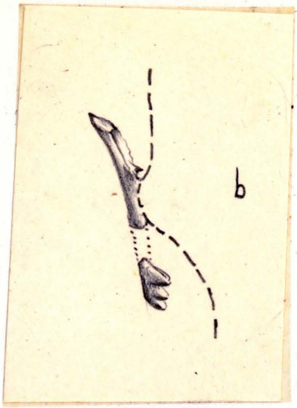
i, impression

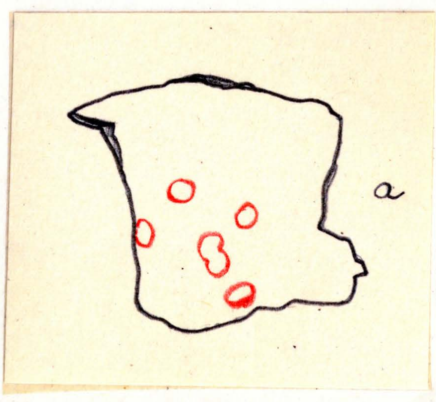
Dashed line indicates margin of rock cover

Magnification; ca. 40 x

Figure 22

Figure 22





Conclusions and Significance

The assemblages described in this report do not offer as many definite relationships from which to conclude as many points as proposed by Scott and others (1934, pp. 453-455). However, they do offer strength in strategic instances and therefore, these conclusions are emphasized. Scott's words are directly quoted in part and in some cases paraphrased to fit the conclusions of the author with the hope that his interpretations have not been obliterated.

(1) "1. Conodonts are paired.

(2) 2. They are made up of right and left groups.

(3) 3. The pairs are laterals instead of uppers and lowers. In some cases it appears as though they may have been grouped around the mouth opening as in the mouth of a modern annelid.-----

(4) 7. -----sets of identical assemblages have been found. This would indicate that the preservation was not accidental but natural.

(5) 10. Even though the preservation has been perfect enough to make available for study certain of the conodonts in their original association, no other parts of the animal have been observed. This would lead to the conclusion that the animal had no other hard parts, such as scales or bones, to be preserved, but was composed of soft tissues."

Such is the case with modern annelids.

(6) "11. Some conodonts are fastened or attached in only the posterior or medial portion, whereas the other end is free. This method of articulation is a condition which seems impossible in fish,----.

(7) 13. There have always been mechanical difficulties in fitting the varied and complicated parts of conodonts into the mouth of a vertebrate. This is not the case with worms." Modern annelids possess similar ingestive apparatus.

(8) "14. ----denticles could not have been used as (a part of the) masticatory apparatus; they would have been worn and the points broken off. However, they could be used in the mouth of annelids to aid the animal in obtaining food without any, or at the most, very little, mechanical wear. This is the use that modern annelids make of their teeth.

(9) 16. The component parts may be directly compared to the individual parts of the jaw apparatus of modern annelids."

(10) No evidence was found to exclude the possibility that conodonts originated as skeletal supports for parapodia-like appendages, nor that the assemblages are actually composed of hard parts from both jaw and parapodia.

(11) The assemblages studied by the writer are generally similar to those studied by Scott. Thus adding support to the theory that generic association in one assemblage is a valid condition representing one individual, and that such an animal was of annelid affinity.

The full significance of conodont assemblages is beyond the scope of this paper. The writer had hoped that his studies might aid in support of the annelid affinities. The question still remains; what to do with the conodonts in the way of classification. Scott did propose a classification of them into a generic system that recognizes several genera "telescoped" into one (Scott, 1942, pp. 298-300). Such a classification might aid paleontologists in using conodonts more intelligently in helping solve stratigraphic problems. Specifically, one such problem involves a vast number of distinct conodont species from a particular locality. If the number actually represents that many different kind of animals in one fauna, it is indeed unusual. Whereas, if several genera are considered to be from one animal, the number is reduced to a size commensurate with the ordinary faunal variety found in a given area.

In previous classification systems, Huddle (1934) devised a family grouping of conodonts having apparent morphological relationships, and Ulrich and Bassler (1926) had done about the same thing. However, Scott initiates the ultimate system by describing two new genera (1942, pp. 298-300), each of which include several specimens previously regarded as distinct generic forms individually.

> "The individual conodonts within the assemblage are referred to by reducing a "form generic" name such as Hindeodella to a com-

mon-noun, hindeodell."

He does not propose to abandon the classification system previously established for individual specimens, but merely intends to supplant it as more assemblages can be found and diagnosed. The nature of this diagnosis (representative of the ultimate classification) can best be shown by quoting the description given for the proposed new genus *Lewistownella*. (Scott, 1934, pl. 58, fig. 5)

> "Natural conodont assemblages made up of hindeodells, prioniods, subbryantods, and cavusgnaths.
>
> Genotype; *Lewistownella agnewi* Scott sp.
>
> Remarks.---The differences between subbryantods and bryantods are so slight that either of these collective groups might reasonably be expected to be associated with the other three types to form the genus *Lewistownella*."

Finally, it must be admitted that this is an advancement upon infirm ground, but promises to stimulate further work which may eventually lead to a more generally accepted position of the place of the conodonts in the animal kingdom.

REFERENCES CITED

Hass, Wilbert H., Morphology of Conodonts, Journel of Paleo., v. 15, n. 1, Jan., 1941, (pp. 71-81)

Huddle, J. W., Conodonts from the New Albany shale of Indiana, Bull. Am. Paleo., v. 21, n. 72, 1934, (136 pp.)

Kirk, Stuart R., Conodonts associated with the Ordovician Fish Fauna of Colorado- A Preliminary Note, Am. Jour. of Sci., s. 5, v. 18, 1929, (pp. 493-496)

Parker, T. J. and Haswell, W. A., Textbook of Zoology, v. 1, 6 ed., Macmillan and Co. Ltd., London, 1947, (pp. 295-336)

Scott, Harold W., The Zoological Relationships of the Conodonts, Jour. of Paleo., v. 8, n. 4, Dec., 1934, (pp. 448-455)

Scott, Harold W., Conodont assemblages from the Heath formation, Montana, Jour. of Paleo., v. 16, n. 3, May 1942, (pp. 293-300)

Treadwell, A. L., Polychaetous Annelids from the Dry Tortugas, Florida, Bull., Am.

Mus. Nat. Hist., v. 30, art. 1, March, 1911, (pp. 1-12)

Ulrich, E. O. and Bassler, R. S., A classification of the toothlike fossils, conodonts, with descriptions of American Devonian and Mississippian species, U.S. Nat. Mus., proc. 68, art. 12, (63 pp.)

ADDITIONAL REFERENCES

Bond, Ralph H., 1947, Ohio shale conodonts, Ohio Jour. Sci., v. 42, (pp. 21-37)

Branson, E. B., and Mehl, M. G., 1933, Conodont studies of Missouri, Univ. Mo. Stud., v. 8, n. 1-4. (pp. 97-106)

Branson, E. B., and Mehl, M. G., 1938, Conodonts from the lower Mississippian of Missouri, Univ. Mo. Stud., v. 13, (pp. 128-137)

Cooper, Chalmer L., 1931, Conodonts from the Arkansas novaculite, Woodford formation, Ohio shale, and Sunbury shale, Jour. Paleo. v. 5, n. 2 (pp. 143-151)

Ellers, E. R., 1934, Annelid jaws from the upper Devonian of New York, Carnegie Mus. Annals, v. 22, (pp. 303-316)

Hass, Wilbert H., 1947, Conodont zones in the upper Devonian and lower Mississippian formations of Ohio, Jour. Paleo., v. 21, n. 2, (pp. 131-141)

Hinde, G. J., 1879, On annelid jaws from the Cambro-Silurian, Silurian and Devonian formations in Canada, and from the lower Carboniferous in Scotland, Geol. Soc. London, Quart. Jour., V. 35, (pp. 370-377)

Holmes, G. B., 1928, A bibliography of conodonts with descriptions of early Mississippian species, U.S. Nat. Mus., proc. 72, art. 5, (pp. 1-38)

James, U. P., 1884, On conodonts and fossil annelid jaws, Jour. Cincin. Soc. Nat. Hist., v. 7, (pp. 143-149)

Pander, C. H., 1856, Monographie der fossilen Fishes des Silurischen Systems der Russich, Baltischen Gouvernements,

Shimer, H. W. and Shrock, R. R., 1944, Index Fossils of North America, John Wiley and Sons, Inc.

Stauffer, C. R., 1938, Conodonts of the Olentangy shale, Jour. Paleo., v. 12, n. 5, (pp. 411-443)

Stauffer, C. R., 1940, Conodonts from the Devonian and associated clays of Minnesota, Jour. Paleo., v. 14, n. 5, (pp. 417-435)

Stauffer, C. R. and Plummer, H. J., 1932, Texas Pennsylvanian conodonts and their stratigraphic relations, Univ. Tex. Bull., n. 3201, (pp. 13-50)

Twenhofel, W. H. and Shrock, R. R., 1935, Invertebrate Paleontology, McGraw-Hill Co.

Ulrich, E. O., 1878, Observations on fossil annelids, and descriptions of new forms, Jour. Cincin. Soc. Nat. Hist., v. 1

Wilmarth, M. G., 1938, Lexicon of geologic names of the United States (including Alaska), U.S. Geol. Sur., Bull. 896